P.2000-004310

[Document]	Patent Application
[Reference No.]	299130
[Application Date]	January 13, 2000
[Addressed To]	Commissioner, Patent Office
[International Patent Classification]	F16C 29/06
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[Deposit Account No.] 001638

[Amount] ¥21,000

P.2000-004310

[List of Attached Documents]

[Article]	Specification	1 copy
[Article]	Drawings	1 copy
[Article]	Abstract of the Description	1 copy

[No. of General Power of Attorney] 9006534

[No. of General Power of Attorney] 9402192

[Confirmed Specification] Required

[Designation of document] SPECIFICATON

[Title of the Invention]

LINEAR GUIDE BEARING APPARATUS

[Claims]

[Claim 1]

A linear guide bearing apparatus, wherein guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls is parallel to or coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside in the curved circuit, a radius of curvature of an inside curve in the curved circuit is reduced to a size not contacting the separator, and a radius of curvature of an outside curve in the curved circuit is enlarged to a size not contacting the inside curve and the separator.

[Claim 2]

A linear guide bearing apparatus, wherein guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent

balls in such a manner that a straight line combining center points of the adjacent balls is parallel to or coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, and a chamfering for preventing interference with the separator is processed at a corner portion of an edge in the ball rolling groove of a main body of the linear guide bearing apparatus furnished with an inside member forming an inside curve in the curve circuit.

[Claim 3]

A linear guide bearing apparatus, in which guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls is parallel to or coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside

and outside of the curved circuit, and has an outer diameter of less than 95% of the ball diameter.

[Claim 4]

A linear guide bearing apparatus, in which guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls is parallel to or coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator simultaneously contacts both curved faces of an inside and outside in the curved circuit while the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls, and concave parts are provided at outer circumferences of the outer diameter of the separator for preventing interference with the inside curve in the curve circuit.

[Claim 5]

A linear guide bearing apparatus, in which guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls is parallel to or coincides to an axial line of the separator, and concave faces in both ends

of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, and the outer diameter face of the separator and the inside curve in the curved circuit slidingly contact.

[Claim 6]

A linear guide bearing apparatus, in which guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls is parallel to or coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, and the separator is provided with a projection on the outer diameter face, and the projection and the inside curve in the curved circuit slidingly contact.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention belongs]

The invention relates to a linear guide bearing apparatus making use of rolling of balls, and in particular to an improvement of a linear guide bearing apparatus interposing separators between the balls.

[0002]

[Related Prior Art]

As a prior art linear guide bearing apparatus making use of rolling of balls, for example, there is, as shown in Fig. 7, a so-called linear guide apparatus which is furnished with a guide rail 1 elongated in an axial direction and a slider 2 movably crossing thereover. The guide rail 1 is defined at both sides with ball rolling grooves 3 respectively in the axial direction. On the other hand, as shown in Fig. 8 being a cross sectional view, a main body 2A of a slider 2 is defined with ball rolling grooves 6 in opposition to the ball rolling grooves 3 at the inside of both wings 4.

[0003]

Both opposite ball rolling grooves 3, 6 form a loading ball rolling path A, and balls K of many steel balls roll while supporting load, so that the slider 2 move on the guide rail 1 in the axial direction. Following this moving, the ball K intervening between the guide rail 1 and the slider 2 moves to an end part of the main body 2A of the slider 2, and for continuously moving the slider in the axial direction, the balls

K must be unlimitedly circulated.

[0004]

Therefore, a linear penetrating hole 7 is formed as a ball returning path axially penetrating in the wings 4 of the slider main body 2A, and at the same time, end caps 5 are equipped at both front and rear ends of the slider main body 2A, where a ball circuit 8 is formed which is curved in half toroid for communicating the loading ball rolling path A of both ball rolling grooves 3 and 6 and the ball returning path 7, thereby to compose an endless ball bearing path. The ball circuit 8 is composed of an outside guiding face 8a and an inside guiding face 8b, the outside guiding face 8a being a semi arc groove formed in the inside end of the end cap 5 being an outside guiding member, and the inside guiding face 8b being an outer circumference of a half pillar shaped inside guiding member 9 (also called as return guide) secured to the end face of the slider main body 2A.

[0005]

Although not shown in Fig. 8, there is also a case that the separator T (also called as retaining piece), as shown in Fig. 9, interposed between the adjacent balls K and K in the unlimited circulating path.

Applicant filed a patent application (JP-A-11-166900) of improving functioning performance by specifying sizes and shapes of the separator T. This is, as shown in Fig. 9, that

the separator T is substantially cylindrical at an outer circumference Q and has concave parts W at both sides for contacting the balls K, and under a condition that the concave faces W contact the balls K, an axial line L of the separator and a straight line combining central points O and O of the balls K and K coincide with, and the radius of curvature of the concave face part W contacting the ball K is almost equal to the radius of the ball K.

[0006]

The separator T has effects of checking zigzag phenomena of the ball to heighten the functioning performance and suppressing noises to heighten noise characteristics. The larger the holding margin of the ball, that is, the larger the outer diameter $L\phi$ of the separator T, the larger the effects, and a maximum outer diameter size is regulated to be sizes interfering with the inside guiding member 9. Fig. 9 shows a condition where the ball K rolls as contacting both of the outside guiding face 8a and the inside guiding face 8b of the ball circuit 8, namely, a condition of "no space and no playing". The maximum value $L\phi$ of the outside dimension of the separator T can be expressed the following (1) formula based on a theorem of three dimensional square.

[0007]

$$L\phi = 2\{(L_R - Da/2)^2 - (L_{SP}/2)^2\}^{1/2} - 2L_r \quad \ldots\ldots\ldots (1)$$

herein,

$L\phi$: the maximum outer diameter when the separator T makes no playing

Da: the ball diameter

L_{SP}: span between balls

L_R: the radius of the outside guiding face 8a

L_r: the radius of the inside guiding face 8b.

Under the condition of "no space and no playing" of the balls K with respect to the inner and outer guiding faces 8a, 8b of the ball circuit 8, since the balls do not always roll smoothly, taking the allowable dimensional precision in production into consideration, it is general to prepare playing of about 10% of the ball diameter between the ball K and the ball rolling circuit 8, irrespective of presence or absence of the separator T.

[0008]

Fig. 10 shows a case of a general ball circuit 8 providing somewhat playing in rolling of the ball K, and the maximum outer diameter size $L\phi_{max}$ of the separator T at this time is expressed by the following formula (2), which can be made larger than the maximum outer diameter $L\phi$ without preparing the playing.

$$L\phi_{max} = 2\{(L_R - Da/2)^2 - (L_{SP}/2)^2\}^{1/2} - 2(L_R - Da - Ld) \quad \ldots\ldots (2)$$

herein,

$L\phi_{max}$: the maximum outer diameter of the separator T (a little playing)

$L\phi$: the maximum outer diameter when the separator T

makes no playing

Da: the ball diameter

L_{SP}: span between balls

L_R: the radius of the outside guiding face 8a

L_r: the radius of the inside guiding face 8b

L_d: the amount of "playing"

[0009]

[Problems that the Invention is to solve]

However, the separator T having the maximum outer diameter size $L\phi_{max}$ under the condition of "with playing" (Fig. 10) of the linear guide bearing apparatus shown in JP-A-11-166900 is involved with the problem that the outer diameter is made as large as possible for heightening the ball holding effect by making a large holding margin, but the interference with the slider main body 2A is created so that it is difficult to provide an improving effect of sufficient functioning performance. In short, as shown in Fig. 10, it is preferable that a little playing is present between the ball K and the inside guiding member 9 in the ball circuit 8, but in contrast, the ball K must not have the playing in the loading ball rolling path A. Thus, a corner portion C which is present at an edge in the loading ball rolling path A equipped with the inside guiding member 9 (return guide) in the ball circuit 8, cannot but inevitably be a little protruded toward the loading ball rolling path A. This protruded corner portion C interferes

with the separator T.

[0010]

The above mentioned patent application discusses that it is effective to regulate the maximum outer diameter $L\phi_{max}$ of the separator T within the range of 60 to 80% of the ball diameter Da. But, when using the separator T as large as possible which is an outer diameter of about 70 to 80% near to the upper limit, the inside guiding face 8b of the inside guiding member 9 is made a composite curve comprising a plurality of curves different in centers and radii of curvature, not a simple semicircle, so that the inside guiding member 9 is remarkably complicated in shape, inviting cost-up.

[0011]

Inventors noticed unsolved problems of the prior art, made studies and found that even if the playing becomes larger to a certain degree between the ball and the inside guiding member in the ball circuit, an effect for heightening the ball holding function by enlarging the outer diameter of the separator T exceeds an effect by the playing, and as a result, the functioning performance of the linear guide apparatus is improved, and have realized this invention.

[0012]

Accordingly, it is an object of the invention to provide a more economical linear guide bearing apparatus where, using a separator T of an outer diameter as large as possible, the

separator can be prevented from interference with a ball circuit or a slider main body, enabling to heighten functioning performance, noise characteristics and durability.

[0013]

[Means for solving the Problems]

For accomplishing the above mentioned object, the invention of claim 1 is a linear guide bearing apparatus, wherein guiding balls have parts which move following a curved circuit regulated by guiding members, a substantially pillar or cylindrical separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls is parallel to coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, a radius of curvature of an inside curve in the curved circuit is reduced to a size not contacting the separator, and a radius of curvature of an outside curve in the curved circuit is enlarged to a size not contacting the inside curve and the separator.

[0014]

The invention of claim 2 is a linear guide bearing apparatus,

wherein guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, and a chamfering for preventing interference with the separator is processed at a corner portion of an edge in the ball rolling groove of a main body of the linear guide bearing apparatus furnished with an inside member forming an inside curve in the curve circuit. [0015]

The invention of claim 3 is a linear guide bearing apparatus, wherein guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum

size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, and has an outer diameter of less than 95% of the ball diameter.

[0016]

The invention of claim 4 is a linear guide bearing apparatus, wherein guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, and concave parts are provided at outer circumferences of the outer diameter of the separator for preventing interference with the inside curve in the curve circuit.

[0017]

The invention of claim 5 is a linear guide bearing apparatus, wherein guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line

combining center points of the adjacent balls coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, and the outer diameter face of the separator and the inside curve in the curved circuit slidingly contact.

The invention of claim 6 is a linear guide bearing apparatus, wherein guiding balls have parts which move following a curved circuit regulated by guiding members, a separator is interposed between adjacent balls in such a manner that a straight line combining center points of the adjacent balls coincides to an axial line of the separator, and concave faces in both ends of the separator in the axial direction respectively contact spherical surfaces of the adjacent balls, characterized in that the separator has a size of an outer diameter more than a maximum size of an outer diameter under a condition where the ball rolls while simultaneously contacting both curved faces of an inside and outside of the curved circuit, and the separator is provided with a projection on the outer diameter face, and the projection and the inside curve in the curved circuit slidingly contact.

[0018]

[Mode for carrying out he Invention]

Explanation will be made to the invention by way of the drawings. The same reference numeral and signs will be given to corresponding parts to those of the prior art for preventing repetition of explanation.

Fig. 1 shows a first embodiment of the linear guide bearing apparatus of the invention, and is a cross sectional view of a part of a curved ball circuit 8 composed of an outside guiding member 5 called as an end cap and an inside guiding member 9 called as a return guide.

[0019]

In this embodiment, separators T shaped in pillar are interposed between adjacent balls K in such a manner that an axial line L of the separator T coincides to a straight line combining center points O of the adjacent balls K. The separator T has concave faces W in both ends in the axial direction, radius of curvature of which is substantially the same radius of curvature of the ball K, and it is sufficient that the concave face of the separator T has an at least vicinity of an outer circumference of the concave face, which vicinity may contact the spherical face of the ball K. A main body of the separator T is not necessarily shaped in pillar, but may be a hollow cylinder or spherical. What is requisite is that the separator T is easy to catch the ball K and a holding margin may be enlarged. From the above viewpoint, it is more advantageous that the

separator T is shaped in pillar than in sphere in the outer circumference, and that the separator has a shape where the concave face and the ball K contact at more outer circumferential parts of the concave faces W at both ends.

[0020]

In the ball circuit 8 where the ball K rotates under no load, as mentioned above, generally the ball is provided with a certain clearance for smooth circulation of the ball and allowable dimensional precision, but a play is caused thereby in the ball rolling to spoil the functioning performance and noise characteristics. With respect to minus effects that the ball playing becomes large in the ball circuit, the invention compensates it by increasing the outer diameter of the separator T so that a larger effect is brought about, thereby to heighten a ball holding function, consequently to improve the functioning performance of the linear guide apparatus.

[0021]

As one of means for increasing the outer diameter of the separator T as large as possible without interfering with the return guide 9 being the inside guide member, the present embodiment reduces the radius of curvature Lrd of the return guide 9 than Lr at time of no playing (shown with a dotted line in Fig. 1). The outer diameter Lϕd of the separator T can be made thereby larger than the outer diameter Lϕ at the time of no playing shown with a broken line and can be expanded until

a maximum outer diameter $L\phi d_{max}$. By increasing the outer diameter of the separator T, it is possible to bring about a plus effect exceeding the minus effect of increasing the playing amount Ldd caused by decreasing the radius of curvature of the return guide 9.

[0022]

Although the interference with the separator T can be avoided by reducing the radius Lr of curvature of the return guide 9, depending on sizes in a space between the outer diameter $L\phi d$ of the separator T and the radius Lrd of curvature of the return guide 9, the separator T interferes with a corner portion C at the edge of a slider main body 2A furnished with the return guide 9 as shown in Fig. 1(b) and protruding toward side of the loading ball rolling path A. For stopping this interference, it is sufficient to chamfer the corner portion C at the end of the slider main body 2A. Thus, it is possible to circulate a still larger separator T by use of a return guide of simple shape as arc, thereby enabling to heighten the functioning performance as lower cost.

[0023]

The relation between the playing amount Ldd and the outer diameter $L\phi d$ of the separator T is expressed by the following formula (3)

$$Ldd = [(Lsp/2)^2 + \{(L\phi d/2) + Lrd\}^2]^{1/2} - Lrd - Da/2 \quad \ldots\ldots (3)$$

herein,

Ldd: the playing amount

Lϕd: the outer diameter of the separator

Da: the ball diameter

Lsp: span between the ball

Lrd: the radius of the reduced inside guiding face 8b

It is seen from this formula that the larger the outer diameter Lϕd of the separator T, the larger the playing amount Ldd. From the results of the actual measurements, it was found that the ball holding effect by the separator T surpassed the minus effect by the playing until a playing amount of a certain degree, and an improvement of the functioning performance was recognized, but if the playing amount was too much, a zigzag phenomenon of the ball could not be controlled, and consequently the improvement of the functioning performance was acknowledged.

[0024]

The allowable maximum outer diameter Lϕdmax of the separator T is regulated by interference with the particular inside guiding member 9 (return guide) among the guiding members. That is, since the separator T is determined such that the axial line of the separator T coincides with the straight line L combining the central points O of the adjacent balls K, if the outer diameter size Lϕd of the separator T is made large, the outer circumferential part comes nearer to the inside guiding member 9, and if making too large, both interfere each other.

When the separator T interferes with the inside guiding member 9, the interference causes to make noises, lower the functioning performance or endurance. Accordingly, the maximum allowable value $L\phi d_{max}$ of the outside dimension of the separator T is a value of contacting the inside guiding member 9.

[0025]

Then, in response to the radius of curvature of the inside guiding face 8b of the return guide 9, separators T of various outer diameters were used, and when ratios between the outside dimensions of those separators T and the diameters of the balls were 0.65 (65%), 0.80 (80%), 0.85 (85%) and 0.95 (95%), variations of dynamic friction of the separators T moving together with rolling of the balls in the ball circuit 8 were measured for evaluating the functioning performance by the outside dimensions $L\phi d$ of the separators T. The measured results are shown in Figs. 2 and 3. The dynamic friction of the linear guide bearing apparatus of the standard without furnishing the separator is shown in Fig. 2(e). In each of the shown graphs, the axis of abscissa is the moving distance (mm) of the separator T, and the axis of ordinate is the dynamic friction (kgf). Among variations in friction force shown therein, sharp variations as shown in Fig. 2(e) are called as beards. Sizes of maximum beard components per each of the separators are compared in Fig. 3. Since the size of the maximum beard component of the standard without the separator is around

0.5 kgf (shown with the dotted line in Fig. 3), if a condition when using the separator is 0.5 kgf or lower, the outside dimension Lϕd of the separator T is preferably less than 0.95 (95%).

[0026]

As mentioned above, the linear guide bearing apparatus of the first embodiment employs the separator T having the outer diameter Lϕd which is more than Lϕ being the outer diameter of the separator T under the condition where the ball K rolls as simultaneously contacting both inside and outside curved faces 8a, 8b in the ball circuit 8, that is, under the condition which is designed such that the playing of the ball K is zero in the ball circuit 8 (or if needed, chamfering the end face of the slider main body continuing to the inside curve 8b of the ball circuit 8), and the instant linear guide bearing apparatus is composed in such a size that the radius of curvature of the inside curve 8b in the ball circuit 8 is reduced to a size not contacting the separator T, otherwise, in such a size that the radius of curvature of the outside curve in the curved circuit is expanded so that the inside curve and the separator do not contact. Thereby, the interference between the ball circuit 8 and the separator T is prevented, and in comparison with the linear guide bearing apparatus having the return guide of the standard size, the instant embodiment displays an effect of more improving the functioning performance and noise

characteristics.

[0027]

Fig. 4 shows a second embodiment of the linear guide bearing apparatus according to the invention.

This embodiment is different from the first embodiment in that a concave 11 is defined in an outer circumference Q of the separator T, following the inside guide face 8b of the ball circuit 8. Therefore, in spite of the outer diameter of the same size as the separator T of the first embodiment, and the concave area of contacting the ball being the same size as in the first embodiment where the outer circumference Q is simple as a cylindrical face, the playing amount Ld can be made smaller, bringing about an advantage of accomplishing lower noises.

[0028]

Fig. 5 shows a third embodiment of the linear guide bearing apparatus according to the invention.

This embodiment contacts the outer circumference Q of the separator T to the inside guiding face 8b in the ball circuit 8 for sliding, and aims at more heightening the functioning performance and noise characteristics by suppressing the zigzag phenomena of the ball K to the most.

Fig. 6 shows a fourth embodiment of the linear guide bearing apparatus according to the invention.

[0029]

This embodiment is different from each of the above mentioned embodiments in that a small projection 12 is provided on the outer circumference Q of the separator T, and via this small projection 12, the separator T contact to the inside guiding face 8b of the ball circuit 8. The contacting area between the separator T and the inside guiding face 8b is made small so as to reduce the frictional force to the most for further heightening the functioning performance and noise characteristics.

Herein, reference will be made to the thickness of the separator T regulating the span between the balls K and K. From the viewpoint of load capacity of the linear guide bearing apparatus, the smaller the thickness of the separator T, the more preferable, but taking elastic deformation or formability of the separator T into consideration, it is reasonable that the thickness of the separator is determined to be around 3 to 10% of the ball diameter. In particular, when the ball is acted with large load, or loaded with large pre-pressure, the thickness of the separator T should be set as large as possible for increasing strength. But the ball span L_{SP} is lengthened thereby and the outer diameter $L\phi d_{max}$ of the separator is made small so that the ball holding forth of the separator T is lowered, and bad influences are probably affected to the functioning performance and noise characteristic. Even in such cases, if applying the invention, the ball holding force of the separator

may be increased and it is possible to prevent bad influences to the functioning performance and noise characteristic.

[0030]

In the above mentioned each of embodiments, explanation has been made to not only the shape of the inside guiding face 8b but also the half toroidal shape where the entire shape of the ball circuit 8 is single arc, but the ball circuit 8 applied with the invention is not restricted to such shapes. For example, elliptic shape, plural arc combined shapes, or coupled shape of arc shape and straight shape may be enough.

[0031]

Shown is that the outer diameter of the separator T is shaped substantially in pillar, and a cylindrical shape having a penetrating hole at the center may be useful.

Explanation has been made to only independent separators T, but respective separators may be combined.

The cases where the linear guide bearing apparatus is applied to the linear guide apparatus are shown, but the invention may be suitably employed to other linear guide bearing apparatus such as linear ball bearings having the curved circuits.

[0032]

[Effects of the Invention]

As mentioned above, according to the invention, the outer diameter of the separator is made as large as possible, and

concurrently the interference between the curved circuit and the separator is limited to the minimum, thereby to assume the effects of enabling to more improve the functioning performance and noise characteristics than the linear guide bearing apparatus of the standard specification without furnishing the separator.

[Brief Description of the Drawings]

[Fig. 1]

Cross sectional views of curved bearing parts showing a first embodiment of the linear guide bearing apparatus of the invention;

[Fig. 2]

Explanatory views of variations in frictional force for evaluating the functioning performance of the separator per each of the outside dimensions with respect to the ball diameter;

[Fig. 3]

An explanatory view of evaluating the outside dimensions of the separators with respect to the ball diameter;

[Fig. 4]

A cross sectional view of the curved bearing part showing the second embodiment of the linear guide apparatus of the invention;

[Fig. 5]

A cross sectional view of the curved bearing part showing the third embodiment of the linear guide apparatus of the

invention;

[Fig. 6]

A cross sectional view of the curved bearing part showing the fourth embodiment of the linear guide apparatus of the invention;

[Fig. 7]

A perspective view of an outer appearance showing one embodiment of the conventional linear guide bearing apparatus;

[Fig. 8]

A cross sectional view in the axial direction including the curved bearing part of the linear guide bearing apparatus of Fig. 7;

[Fig. 9]

A cross sectional view of the curved bearing part showing the maximum outer diameter of the separator under the condition of "no space and no playing"; and

[Fig. 10]

A cross sectional view of the curved bearing part showing the maximum outer diameter of the separator with spaces.

[Description of the Reference Numerals and Signs]

5 ... Outside guiding member (end cap); 8 ... Curved circuit; 8a ... Outside guiding face; 8b ... Inside guiding face; 9 ... Inside guiding member (return guide); C ... Corner part at an end face; K ... Ball; T ... Separator; O ... Central part (of the ball); TL ... Axial line (of the separator); and

W ... Concave face

[Designation of Document] ABSTRACT

[Abstract]

[Problem]

To offer a linear guide bearing apparatus interposed with a separator having an outer diameter as large as possible, thereby enabling to improving functioning performance, noise characteristics and durability.

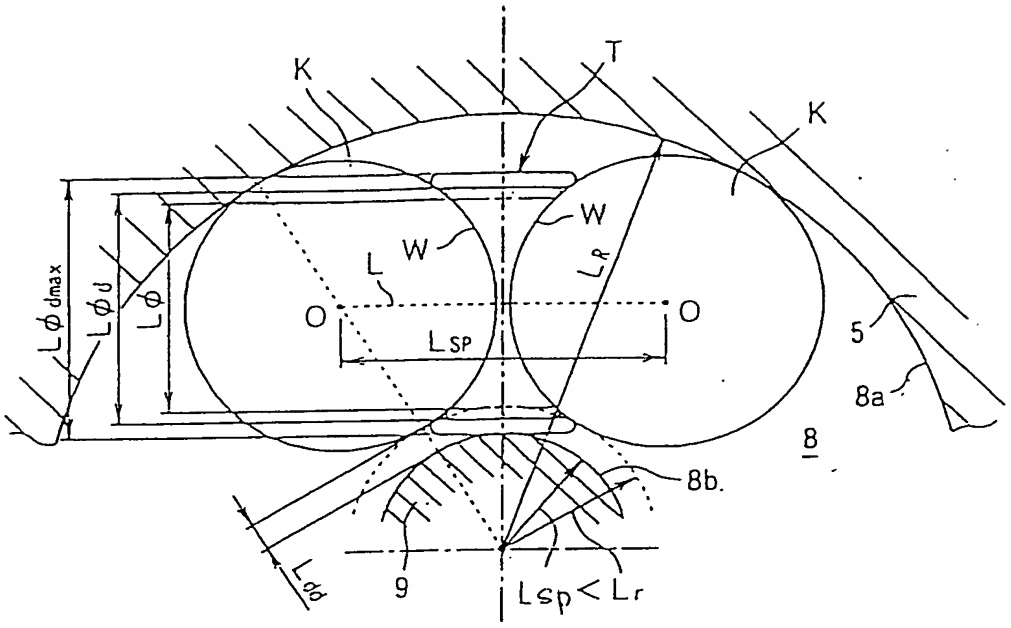
[Means for Resolution]

In a linear guide bearing apparatus wherein a separator is interposed between adjacent balls K and K moving following a curved circuit 8, and the ball K contacts concave faces W of the separator T at both ends in an axial line direction and at the same time the ball K rolls as contacting a guide face 8a of an outside guiding member 5 and a guide face 8b of an inside guiding member 9, the separator has an outer diameter larger than a maximum outer diameter Lϕ under a condition where the ball rolls as simultaneously contacting both curved faces 8a, 8b of the inside and the outside of the curved circuit 8, and the radius of curvature of the guiding face 8b in the curved circuit 8 is reduced to a size not contacting the separator T.

[Selected view] Fig. 1

Fig. 1

(a)



(b)

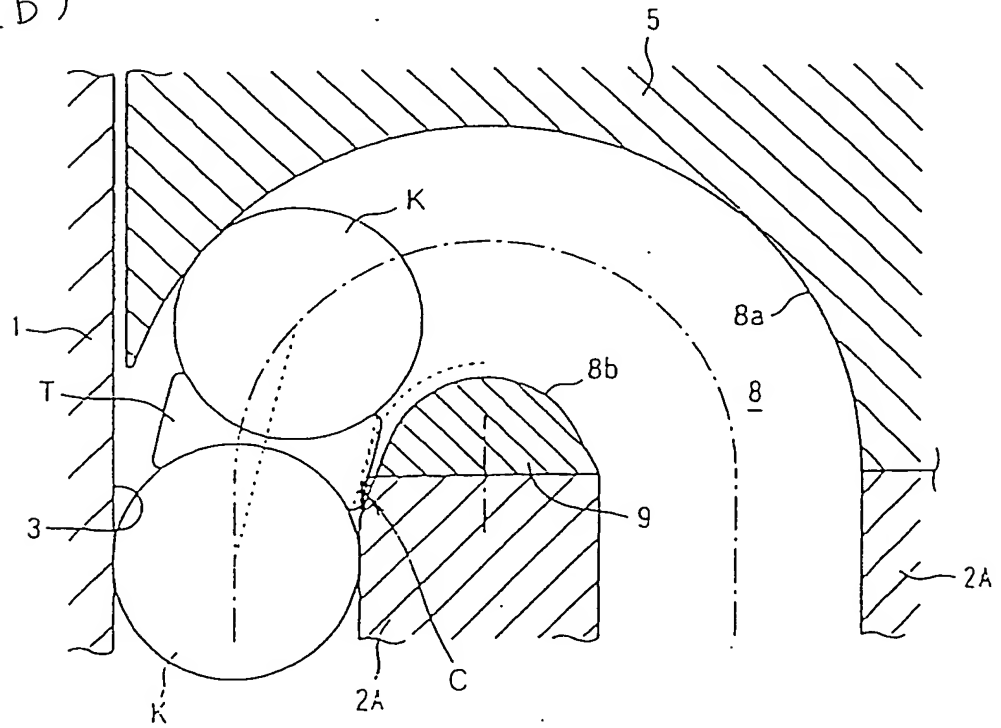


Fig. 2

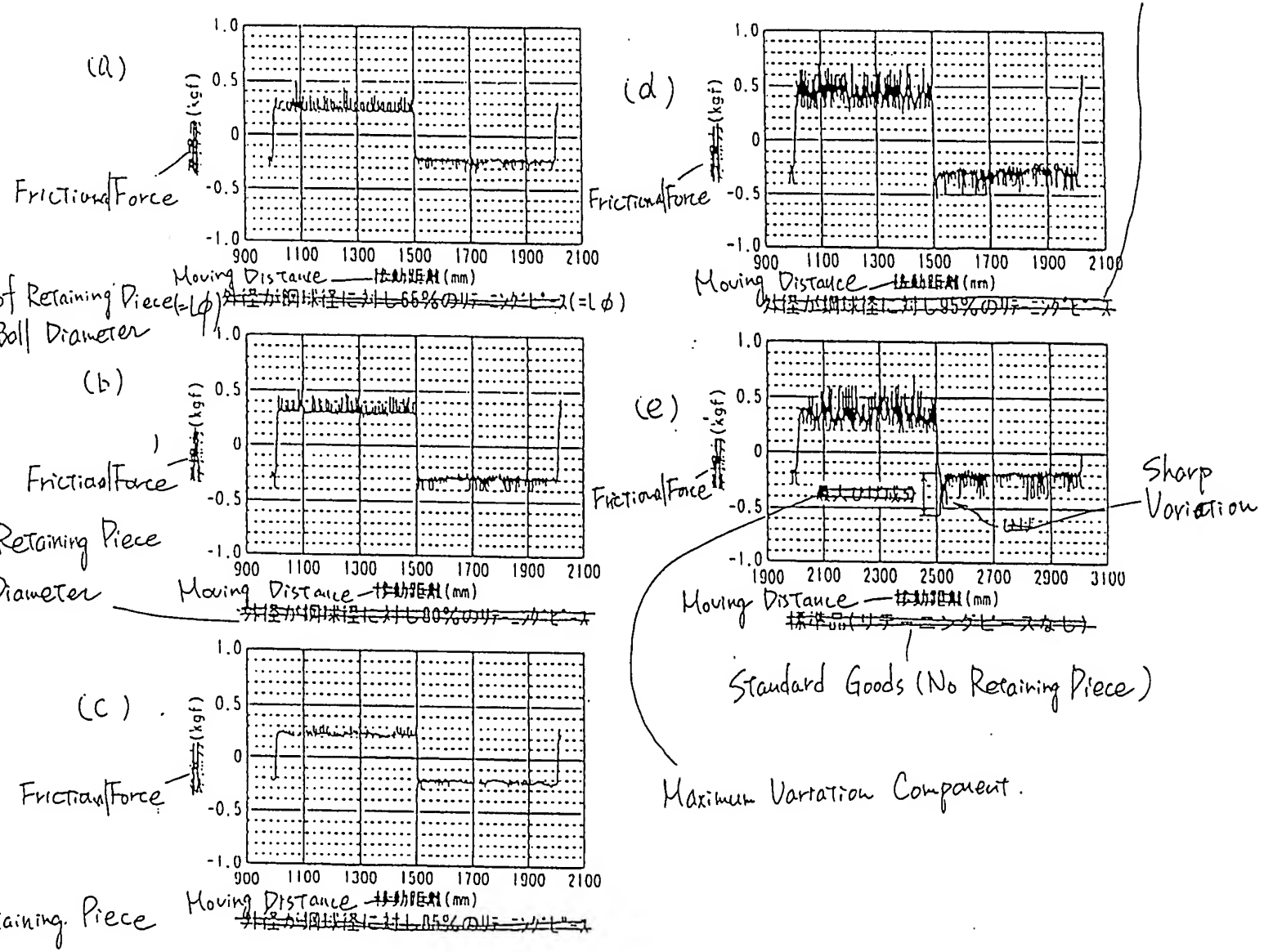

(a)
Outer Diameter of Retaining Piece
: 65% of Steel Ball Diameter
(b)
Outer Diameter of Retaining Piece
: 80% of Steel Ball Diameter
(c)
Outer Diameter of Retaining Piece
: 85% of Steel Ball Diameter
(d)
Outer Diameter of Retaining Piece
: 95% of Steel Ball Diameter
(e)
Sharp Variation
Standard Goods (No Retaining Piece)
Maximum Variation Component.
Frictional Force
Moving Distance
1.0
0.5
0
-0.5
-1.0
900
1100
1300
1500
1700
1900
2100
2300
2500
2700
2900
3100

Fig. 3

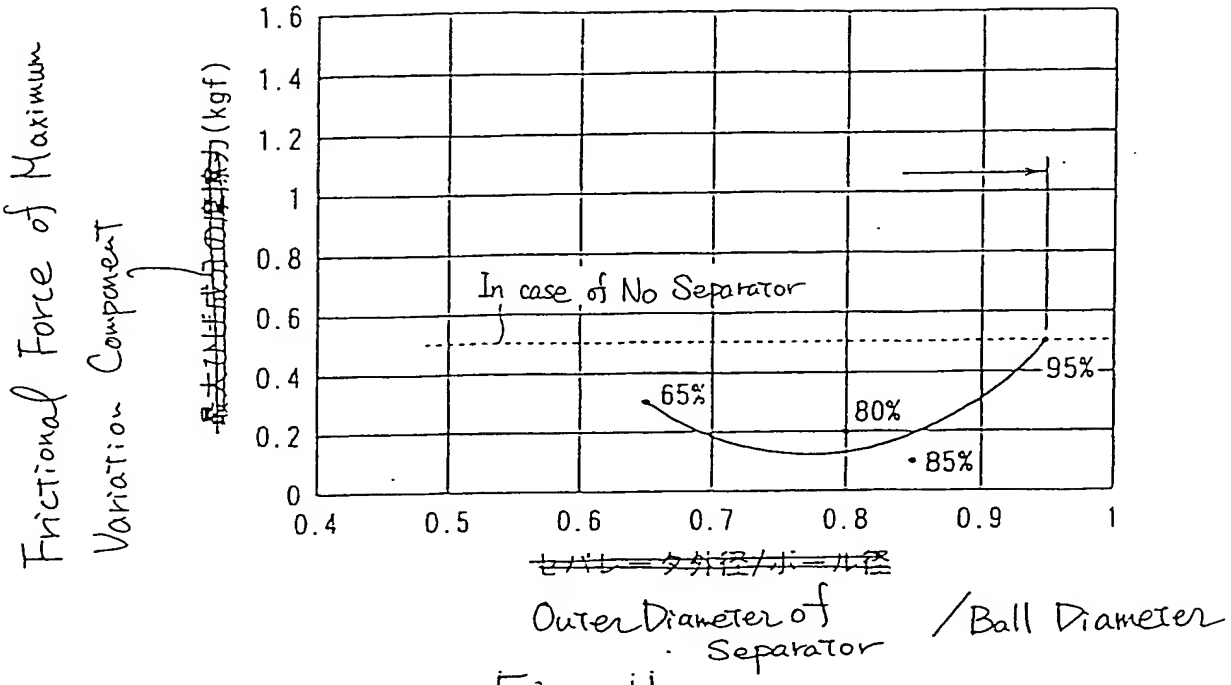

Frictional Force of Maximum Variation Component
(kgf)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.4
0.5
0.6
0.7
0.8
0.9
1
In case of No Separator
65%
80%
85%
95%
Outer Diameter of Separator
/Ball Diameter

Fig. 4

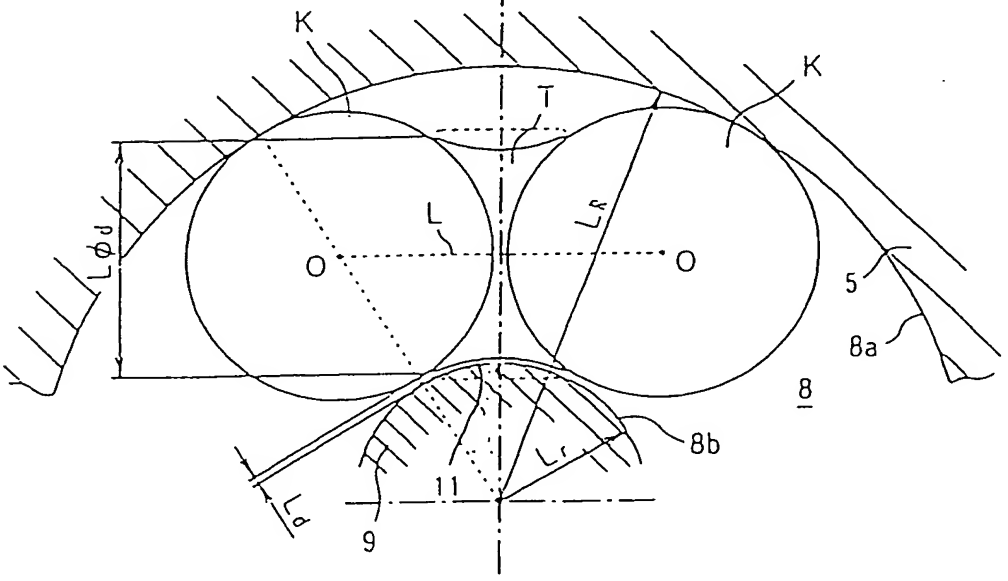

K
K
T
L
Lφd
O
O
La
5
8a
8
8b
Lr
11
La
9

Fig. 5

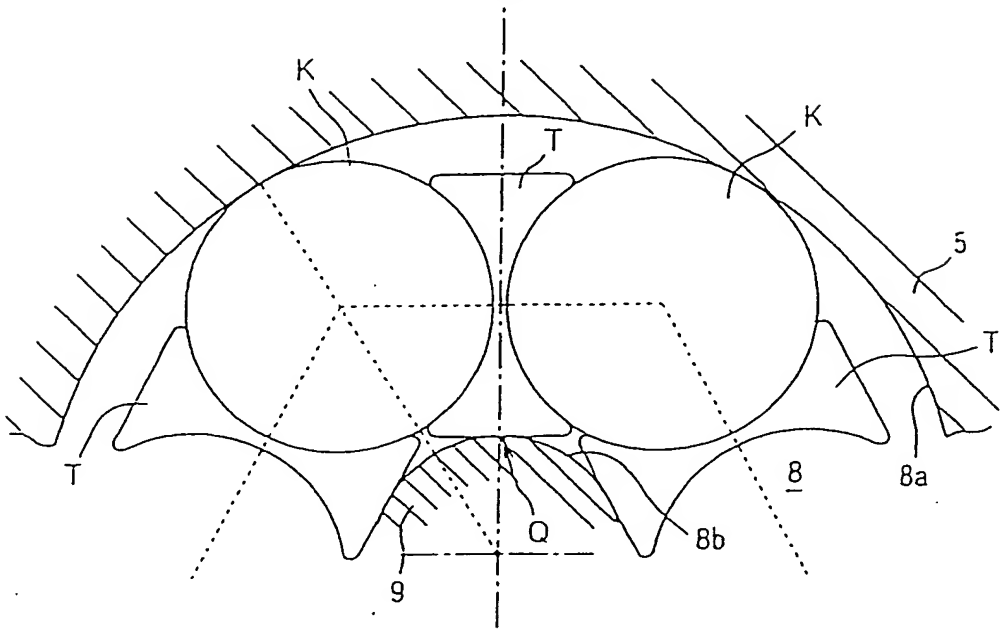


Fig. 6

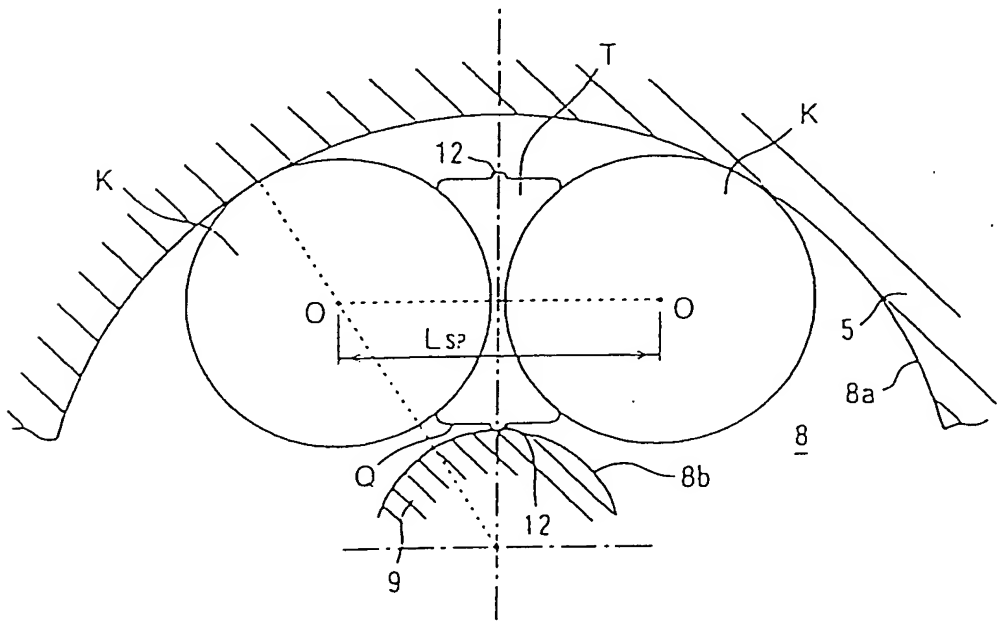


Fig. 7

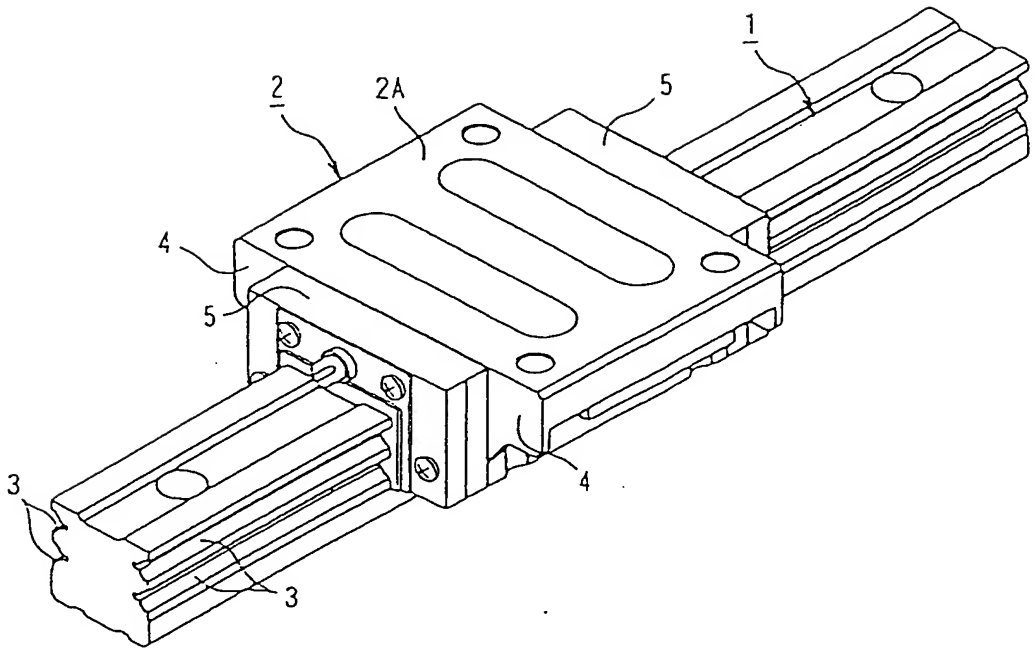


Fig. 8

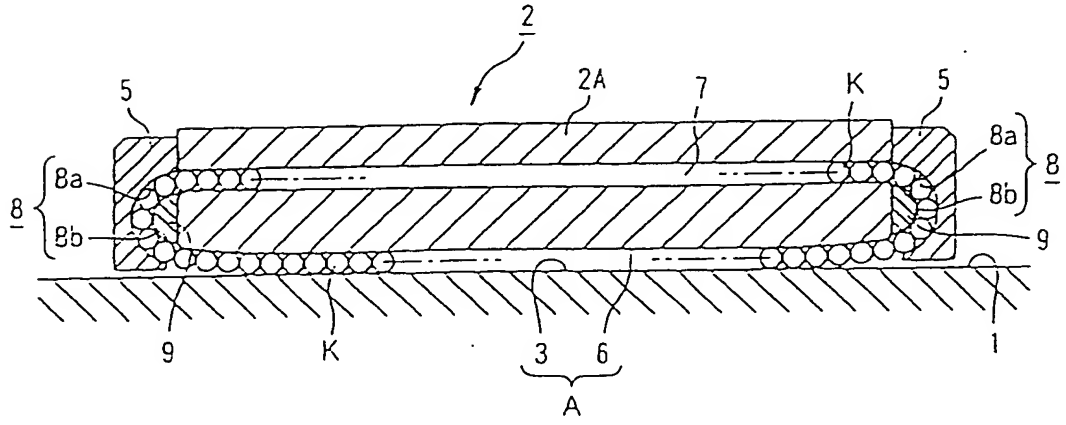


Fig. 9

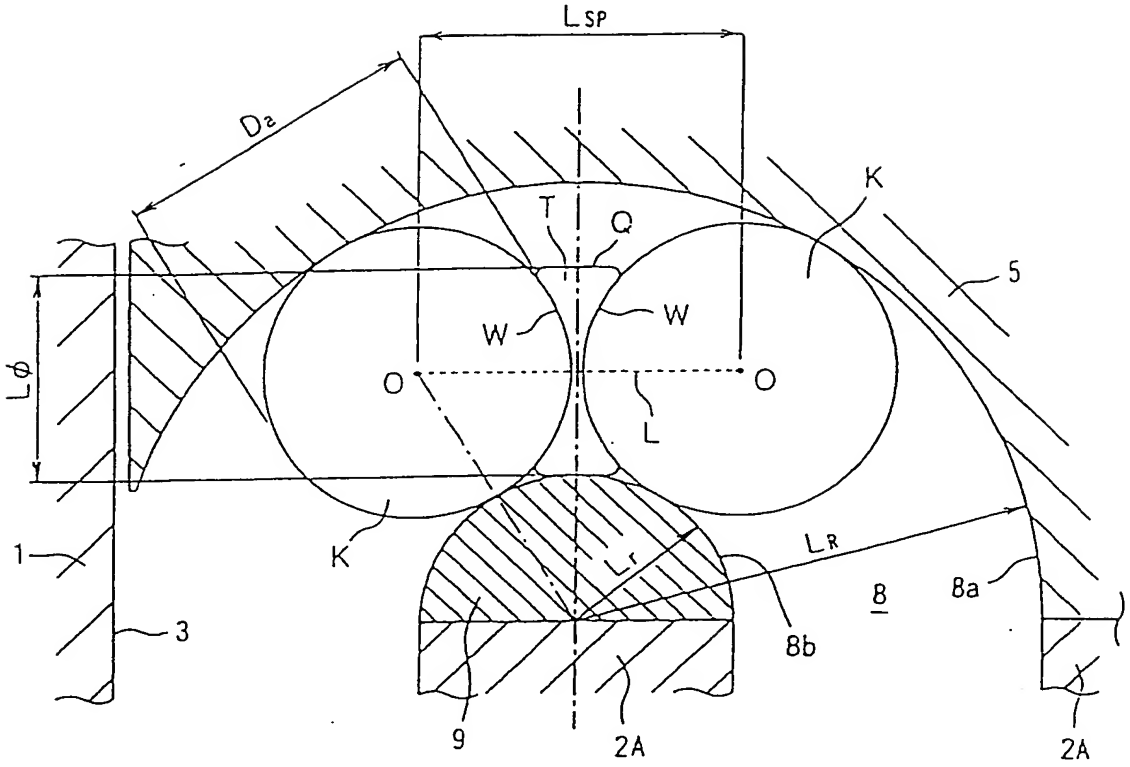
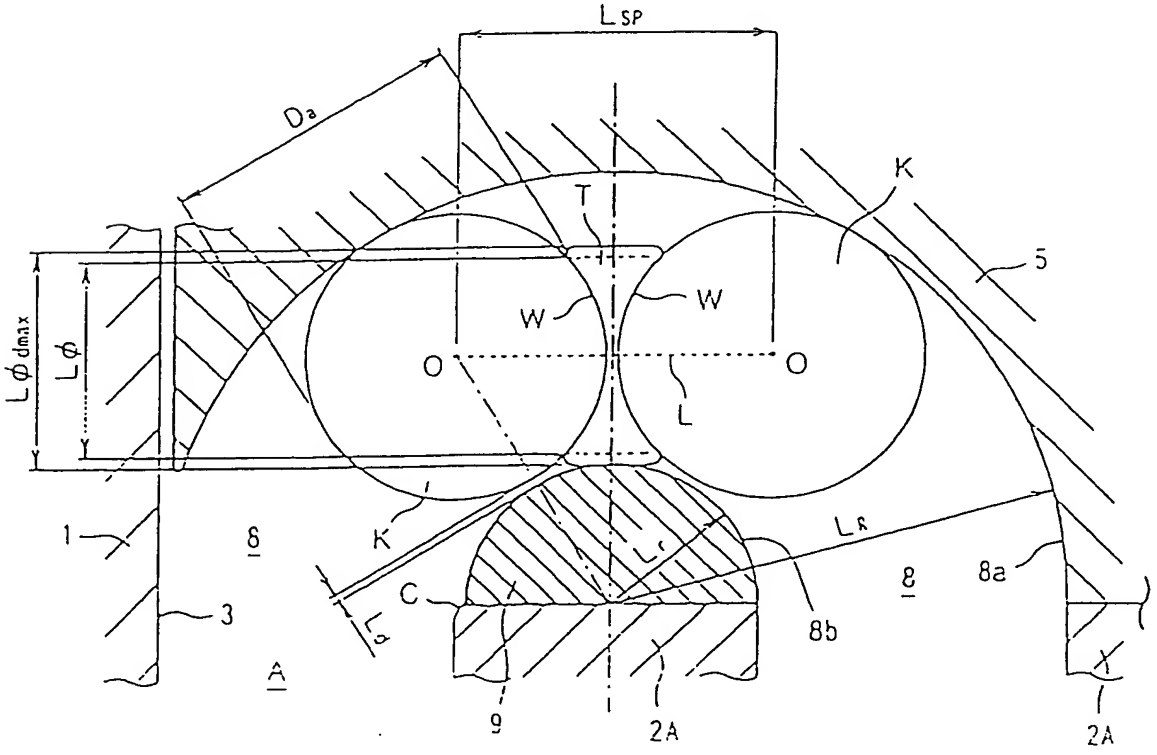

L SP
D2
K
T
Q
5
W
W
Lφ
O
O
L
1
K
Lr
LR
8
8a
3
8b
9
2A
2A

Fig. 10


L SP
D2
K
T
5
W
W
Lφdmax
Lφ
O
O
L
1
8
K
Lr
LR
8
8a
3
C
Lb
8b
A
9
2A
2A